CHAPTER 3

WOODEN CONTAINERS AND PALLETS

CONTAINER MATERIALS

WOOD AS A CONTAINER MATERIAL

Wood is particularly valuable as a container material because of its high strength-weight ratio which compares favorably with mild steel. Tests and experience have shown that the strength of a wooden container depends largely upon the type of wood used in its construction. The durability of wood and its ability to withstand shock and impact stresses are important properties in the selection of wood for containers. Military Handbook MIL-HDBK-7, "Lumber and Allied Products", provides a ready source of information on wood products normally procured in considerable quantity for Department of Defense installations. This handbook is not intended for reference in purchase specifications or other contractual documents. However, it will assist materially with installation requisitioning, receiving, inspection, storage, and handling of container wood materials. Also see ASTM D 6436, Quality of Wood Members for Containers and Pallets.

Wood Groups

All woods fall into two general categories: Either softwoods, which come from coniferous or needle-bearing trees; or hardwoods, which come from broad-leafed trees. For purposes of container construction, wood is divided into four groups based on nail holding power, tendency to split, comparative strength as a beam, and shock resisting capacity (fig 3-1). Over 90 percent of all wooden containers are made from Group I and II woods however, the materials given in Section 3 of the applicable container specification must be used. When a wood group is specified in the contract, any species in that group may be selected.

Group I includes the softer woods such as white fir, ponderosa pine, yellow poplar, cottonwood, cedar, and others. These woods are relatively free from splitting when being nailed, have a moderate nail-holding power, moderate strength as a beam, and moderate shock resisting capacity.

Group II includes the harder soft woods such as Douglas fir, southern pine, hemlock, and larch. They have greater nail-holding power than the Group I woods, as well as greater strength and shock resisting capacity. Group II woods are more inclined to split, the grain often deflects nails and causes them to run out at the side of the piece.

Group III includes the medium density hardwoods. Ash, elm, and cherry are examples. These are similar to Group II woods in nail-holding power and strength as a beam, but have less tendency to split and shatter under impact.

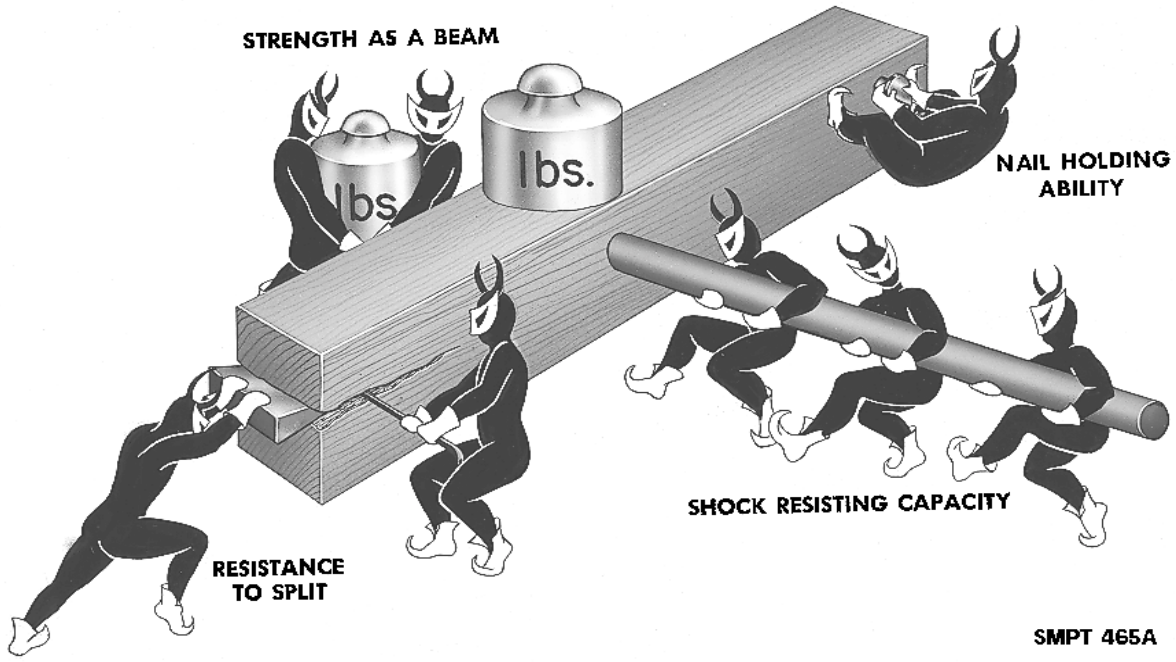

Figure 3-1. Characteristics for the classifications of wood.

Group IV includes the true hardwoods such as oak, hard maple, and hickory. These woods have the greatest shock resistance and nail-holding power, are extremely strong, but are very susceptible to splitting. They are the heaviest and hardest woods, and are difficult to work.

Wood Defects

All boards should be cut to the correct length and be free from all defects that materially weaken them, expose the contents of the box to damage, or interfere with the prescribed fabrication or nailing (fig 3-2).

Knots. Knots in wood are most weakening when located in the middle third of the length of the board. Across the width of the board, the weakening effect is proportional to the effective diameter of the knots, measured as shown in fig 3-3. No knot, or series of knots across the face of the board, within a length equal to the width of the board, shall have a diameter or sum of diameters greater than one third the width of the board. No knot will exceed 4 inches when measured across the width of the board.

Slope of grain. Any board with a slope of grain steeper than a ratio of 1 in 10 of length is not permissible. Figure 3-2 shows the results of excessive slope or cross grain.

Moisture Content

It is important that the moisture content of lumber required by an applicable container specification be followed. High moisture content in lumber will cause excessive tare weight. Shrinkage, due to the loss of high moisture content in the boards of a nailed wood box will cause gaps between the pieces of lumber. Shrinkage will also cause the loss of nail holding-power, splitting of the lumber at the nails, and the loosening of straps. Moisture content is determined by the use of electric moisture meters or by the oven dry method, as outlined in ASTM D 2016.

Moisture Meter Method

The moisture meter method is faster than the oven dry method, but less accurate. A moisture meter consists essentially of an electrical device designed to measure the resistance or the capacitance of the wood between two electrodes in contact with the sample. The values obtained will vary with the water content of the wood. They will also vary as a result of a number of other factors, most important of which are they temperature of the wood, its species, and density. Although correction tables are furnished with each instrument which must be used for even approximations of true values, the readings obtained are still only approximations because the effect of the other variables cannot be determined with scientific accuracy. Instruments of this type cannot be used where an accuracy of plus or minus 1 percent is required. In view of this, the moisture meter method is primarily usable for screening inspections of large lots of lumber, while the oven dry method is almost always resorted to in the event of disputes. The meter used should be capable of giving instantaneous readings of moisture content within a range of 7 to 20 percent, and should be equipped with correction tables to permit the correction of meter readings for temperature, species, and density. The meter should be adjusted prior to use in accordance with the manufacturer's instructions. When a series of readings are being made, the adjustment should be checked periodically. Batteries should be replaced whenever initial adjustment cannot be accomplished, or whenever it is obvious that inaccurate readings are being obtained because of weak batteries. The following general precautions should be observed:

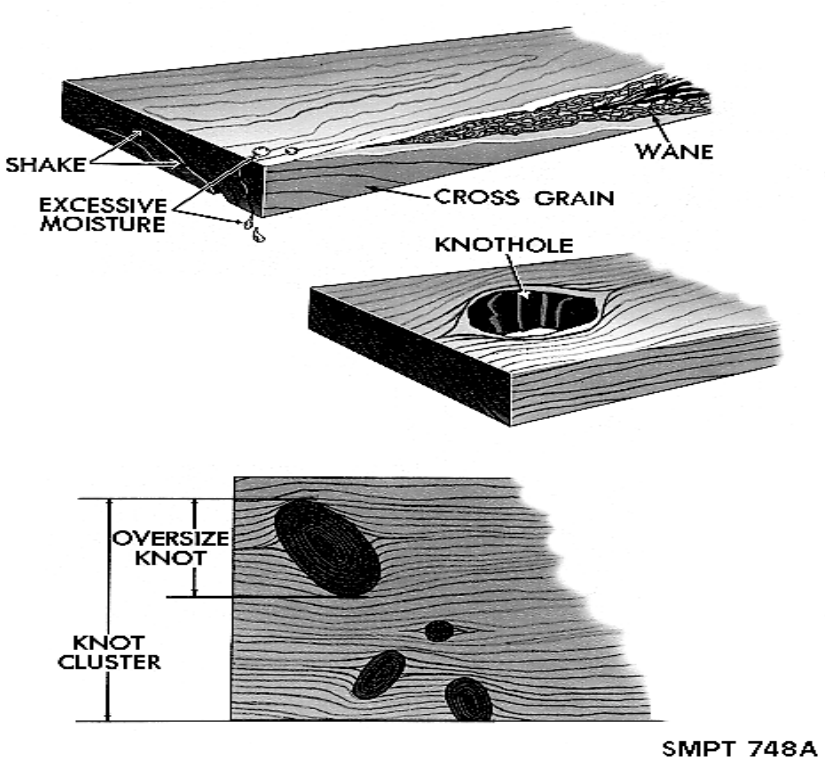

Figure 3-2. Wood defects.

- The entire area of plate-type electrodes should be in contact with the wood. Do not use this type of electrode on rough wood.
- Drive the needle-type electrodes to their full depth and in such a manner that the flow of current will be parallel to the wood grain. When wood splitting occurs discard the reading obtained. Where the wood is over one inch thick, drive 1 1/4 to 1 1/2 inch nails, spaced the same distance apart as the electrodes, straight into the wood to a depth equal to approximately one-fifth the thickness of the piece. These nails must not be cement coated but may be either bright or chemically etched.
- Never use the meter on wood whose surface is wet with rain, dew, or fog.
- Never use the meter on the ends of a piece.
- Never use the meter on a painted or otherwise finished piece.
- Never use the meter on composite pieces where the current between the two electrodes will have to pass through a glue joint.
- Do not use the meter on a piece just removed from the kiln since the temperatures correction tables (which are concerned with the temperature of the piece) will not be applicable.
- On thin pieces, do not support the piece on another piece of lumber, metal, or other material which may give false electrical readings.

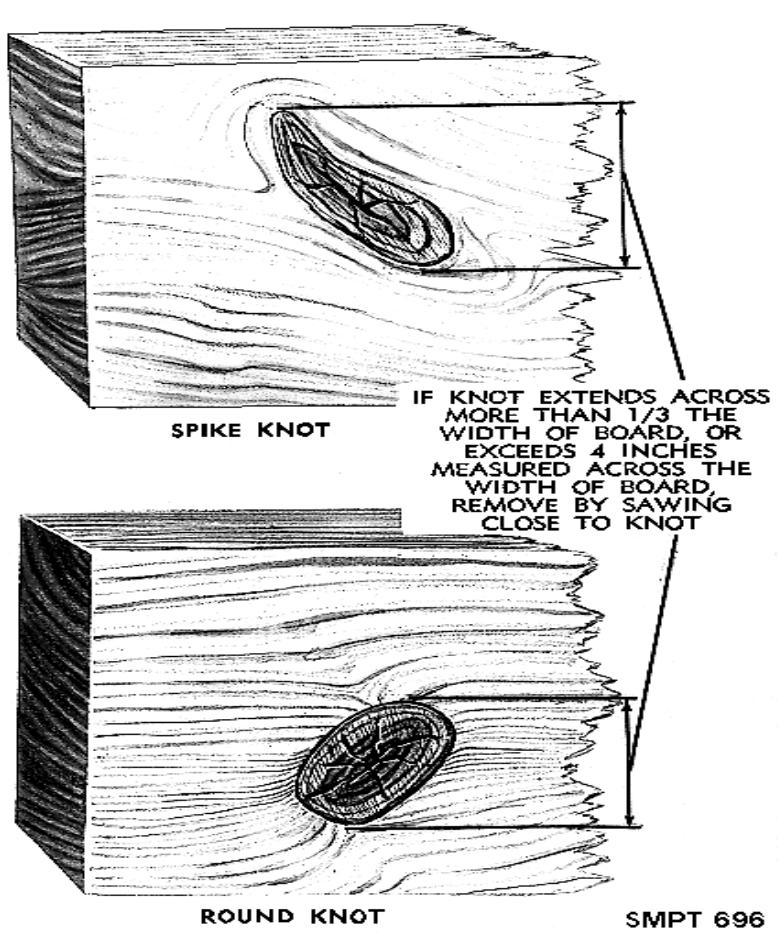

Figure 3-3. Measuring knot diameters.

Oven Dry Method

Use a drying oven capable of maintaining a constant temperature of 212°F. to 221°F., and a scale that is acurate to within one-half of 1 percent. To determine the moisutre content, use the following procedure:

- Cut off a least the first 12 inches of the piece in order to avoid the effects of end drying.
- As soon as possible, cut off a piece approximately 1 inch the full thickness by the full width of the piece.
- Immediately after sawing, remove all loose splinters and determine W, the weight before drying.
- Place the wood in the hot oven and leave overnight. The next day, weigh the specimen and replace in the oven. Repeat at 2-hour intervals until the weight is the same at the end of two successive 2-hour periods. This will occur after approximately 24 hours. If more than one, specimen must be open-piled in the oven to allow free access of air to all parts of the pieces.
- The final weight of the piece immediately after removal from the oven is D, the oven dry weight.
- Calculate the percentage of moisture content by using the following formula:

$$\frac{(W-D)}{W} \times 100 = \%\ \text{Moisture}$$

OTHER MATERIAL SKIDS USED IN CONTAINER CONSTRUCTION

The following additional materials are used in container construction as applicable.

Nails (ASTM F 1667-95)

These may be box, corker, sinker, cooler, or common nails. Sinker and cooler nails are relatively slender, can be driven into denser woods and withstand shocks well. The heads do not break off or pull through the wood easily (fig 3-4). The resistance of nails to withdrawal varies with a number of factors such as the hardness or density of the wood, surface condition of the nails and the shape and form of nails. Dense woods hold nails much better than soft woods. To get the same nail strength with softer woods, more nails or larger nails are required. The use of chemically etched or coated nails is particularly important with soft woods. Resistance of nails to withdrawal also varies with the area of contact of the nail with the wood, increasing directly with the diameter of the nail and the depth of penetration. Nails may be subjected to forces which withdraw them directly, that is, in the direction of their length, or to forces which displace them laterally. Nails offer greater resistance to lateral displacement than to direct withdrawal. Cement coating or etching increases the resistance of nails in direct withdrawal more than in lateral withdrawal, since the nail shank is distorted in lateral withdrawal about the same, whether coated or uncoated. Etched nail surfaces have certain advantages over cement coated surfaces. The effect of etching in increasing withdrawal resistance is relatively permanent, while cement coatings deteriorate a few months after nailing. Etched nails are effective with woods of all densities, while cement coatings tend to rub off when nails are driven into dense woods. Here is a simple procedure for etching nails. Prepare a 10 percent solution (by weight) of commercial monoammonium phosphate in water. Do not use metal container for preparing or storing the solution. Keep the solution near room temperature (about 68°). Immerse the nails in the solution for about 7 hours, stirring

occasionally. Five gallons of solution is sufficient to etch about 100 pounds of nails and rinse with water. Finally, airdry the nails to prevent rusting.

Screws (FF-S-111) Sometimes it is particularly desirable to use screws for closing wooden boxes when the contents are such that they need to be checked, lubricated, or inspected.

Corrugated Fasteners (FF-F-133)

Corrugated fasteners are used in the construction of built-up faceboards in wooden boxes (figure 3-11). When used for this purpose, nailing machine operators do not have to align each board prior to nailing. Corrugated fasteners also help to prevent pilferage of contents during storage or shipment.

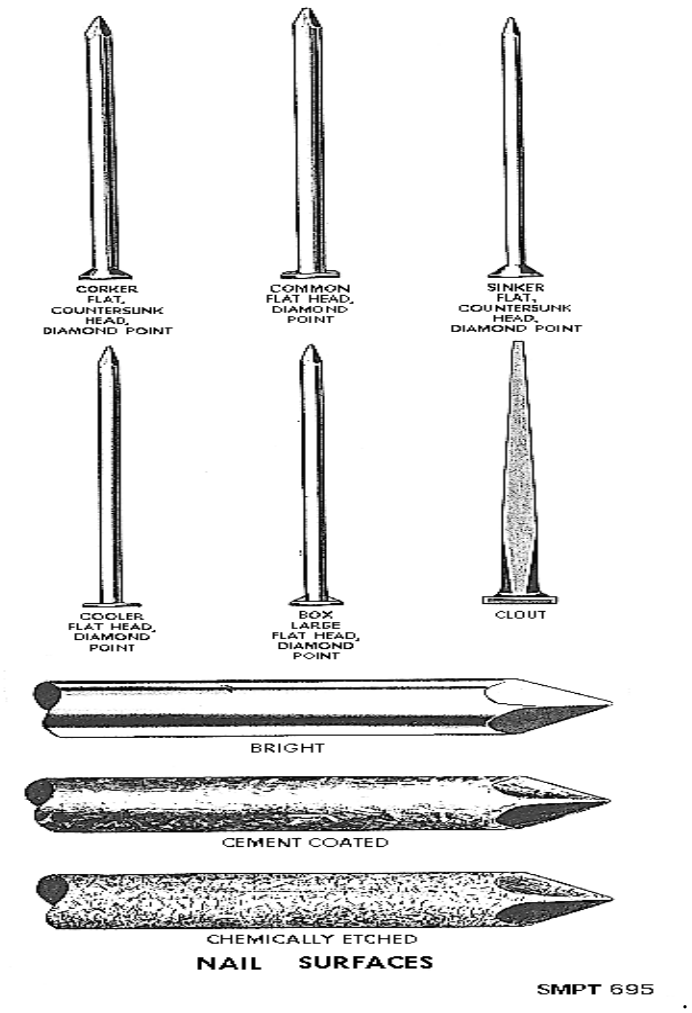

Figure 3-4. Nails.

Staple (ASTM F 1667)

Staples are used to attach cleats to panels on cleated-panel boxes. Staples with crowns not less than one-half inch must be long enough to penetrate the thickness of both the panel material and the cleat with a minimum clinch of one-eighth of an inch.

Wire Fasteners

Fasteners, other than nails, and staples, may be used to attach cleats to plywood or veneer panels. They must provide lateral displacement equal to that of nails properly spaced and driven. Wire fasteners are formed and driven by machine from a roll of knurled wire.

Strapping

Either flat metal or round wire conforming to ASTM D 3953, ASTM D 4675, and ASTM D 3950, to strap wooden containers.

Plywood (A-A-55057)

Plywood used for boxes, either for domestic or oversea destinations, shall be as specified in the procurement document or other directive establishing the container requirements. Plywood will be purchased in accordance with A-A-55057.

Fiberboard (ASTM-D-4727)

For oversea cleated panel boxes, solid V-board with a minimum dry bursting strength of 400 pounds is the only material authorized. For domestic cleated panel boxes, either solid fiberboard, solid pulp-board, or double-faced corrugated board may be used.

Paper Overlaid Veneer

This material, made of thin veneer covered on both faces with heavy kraft paper, is used as panelling material for paper overlaid veneer boxes, conforming to PPP-B-576.

NAILED AND LOCK-CORNER WOOD BOXES (PPP-B-621)

DESCRIPTION AND SELECTION

The nailed wood box is constructed of wood, assembled by fastening the top, sides, and bottom to the ends with nails, or by gluing the lock-corners of the sides and ends and fastening them to the top and bottom with nails. The placement of cleats on the ends or the lack of cleats determines the style of box. Nailed wood boxes will not be used if fiberboard or less expensive light-weight boxes will provide adequate protection for shipment and storage.

CHARACTERISTICS

Nailed wood boxes are satisfactory shipping containers for supplies and equipment, especially for items that are susceptible to damage. These containers have the following favorable and unfavorable characteristics.

- Favorable characteristics.
  - o Maximum protection to contents against damage due to puncture, distortion, and breakage.
  - o Ability to support loads due to stacking during transit and storage.

- Ability to contain difficult loads without undue distortion.
- Adaptability to complex wood blocking and bracing.
- Adaptability to varying strengths by adjusting the style of box, thickness of materials, and group of wood.
- Easy workability and simple construction.

- Unfavorable characteristics.
  - High tare weight and cube.
  - Not watertight.
  - Tendency to crack.

Class and Grades (Fig 3-5)

The classes of nailed wood boxes are--

- *Class 1, domestic boxes.* These boxes are subject to storage, rehandling, or shipment to domestic destinations in which no sea transportation is involved. Net weight is limited to a maximum of 600 pounds (see tables 3-1 and 3-2).
- *Class 2, oversea boxes.* These boxes are subject to storage, rehandling, or reshipment to offshore and oversea destinations. Net weight is limited to a maximum of 1,000 pounds. Class 2 boxes (all styles) shall be furnished in the following grades, as specified. When no grade is specified in the contract, purchase order, or other procurement document, Grade B shall be supplied (see tables 3-3 and 3-4).
  - Grade A--With preservative treatment.
  - Grade B--Without preservative treatment.

Styles and Limitations

Class 1 and 2 boxes are described simultaneously, as applicable, in the coverage of the box styles. Styles 1, 2, 2 1/2, 4, 4 1/2, 5, 6, and 7 are permitted for Class 1 (domestic) and Styles 2, 2 1/2, 4, 4 1/2, 5, and 7 are permitted for Class 2 (oversea) shipments. Weight limitations for each class, as applicable, are given under the description of each style of box.

Style 1 Box (fig 3-6)

Style 1 box is identified by lack of cleats on the end faceboards and single line nailing of sides to ends, and of top and bottom to ends and sides. Style 1 box is intended for domestic shipments only. It is restricted to Type 1 and 2 loads. Style 1 box may not exceed a load limit of 50 pounds for two-piece sides and 100 pounds for one-piece sides. Direction of the grain on Style 1 box must run in the direction of the greatest dimension. This box is limited to a height of 10 inches and total dimensions (length, width, and depth) of 50 inches.

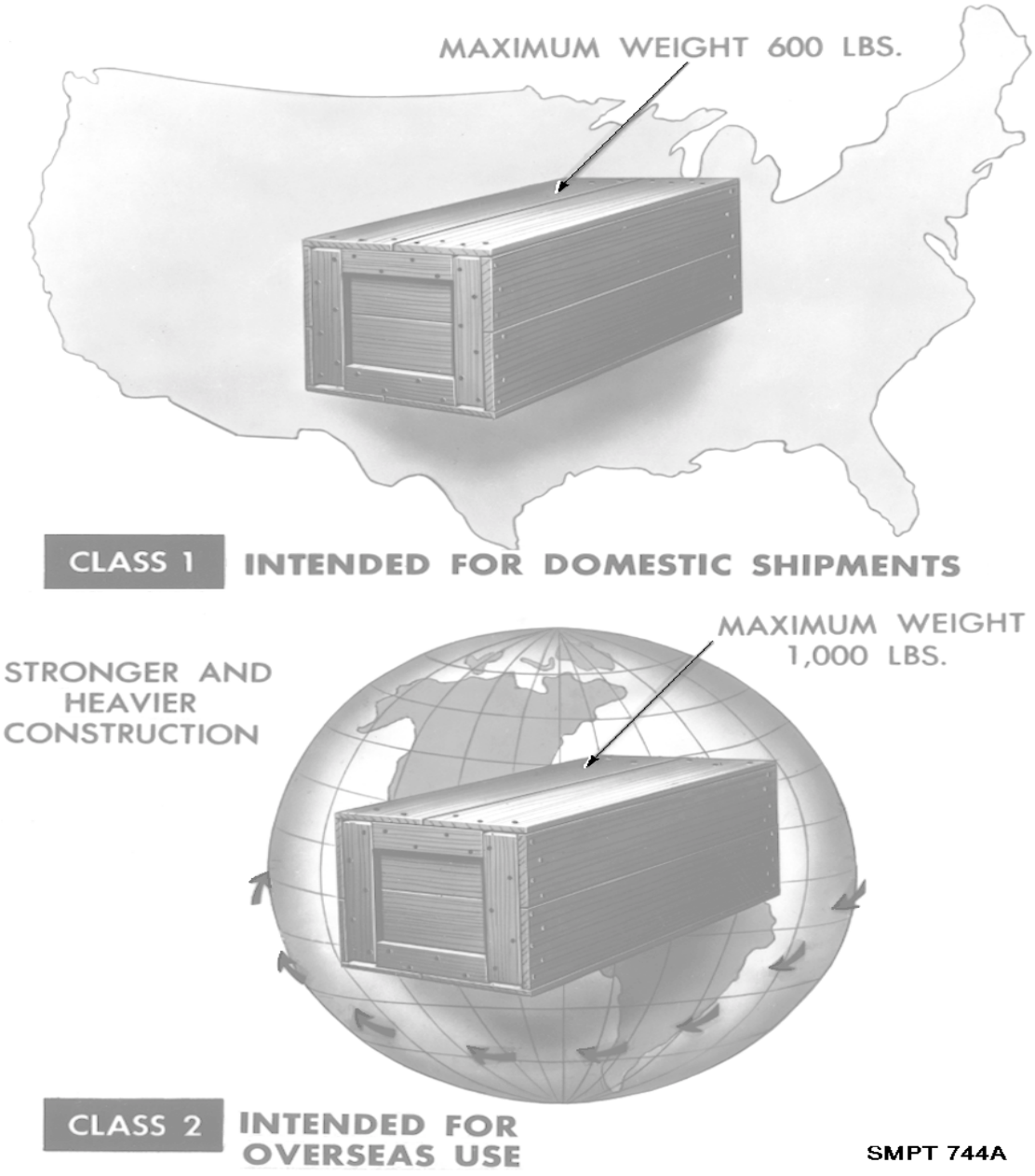

Figure 3-5. Classes of nailed wood boxes.

Style 2 Box (fig 3-6)

Style 2 box is identified by two vertical and two horizontal cleats on each end. Vertical cleats are positioned at right angles to the grain of the end. They are one-eighth of an inch shorter than the edge of the end at the top and bottom. Horizontal cleats, which are placed parallel to the grain of end, are butt-joined to the vertical cleats and are flush with the top and bottom edges of the box. The top, bottom, and sides extend over the ends and cleats and are nailed in a staggered pattern. Thus, there is some side-grain nailing on all edges. The cleat pattern provides ease of handling. Weight limitation for Style 2, Class 1 box (domestic) is 600 pounds. Weight limitation for Style 2, Class 2 (oversea) box is 1,000 pounds.

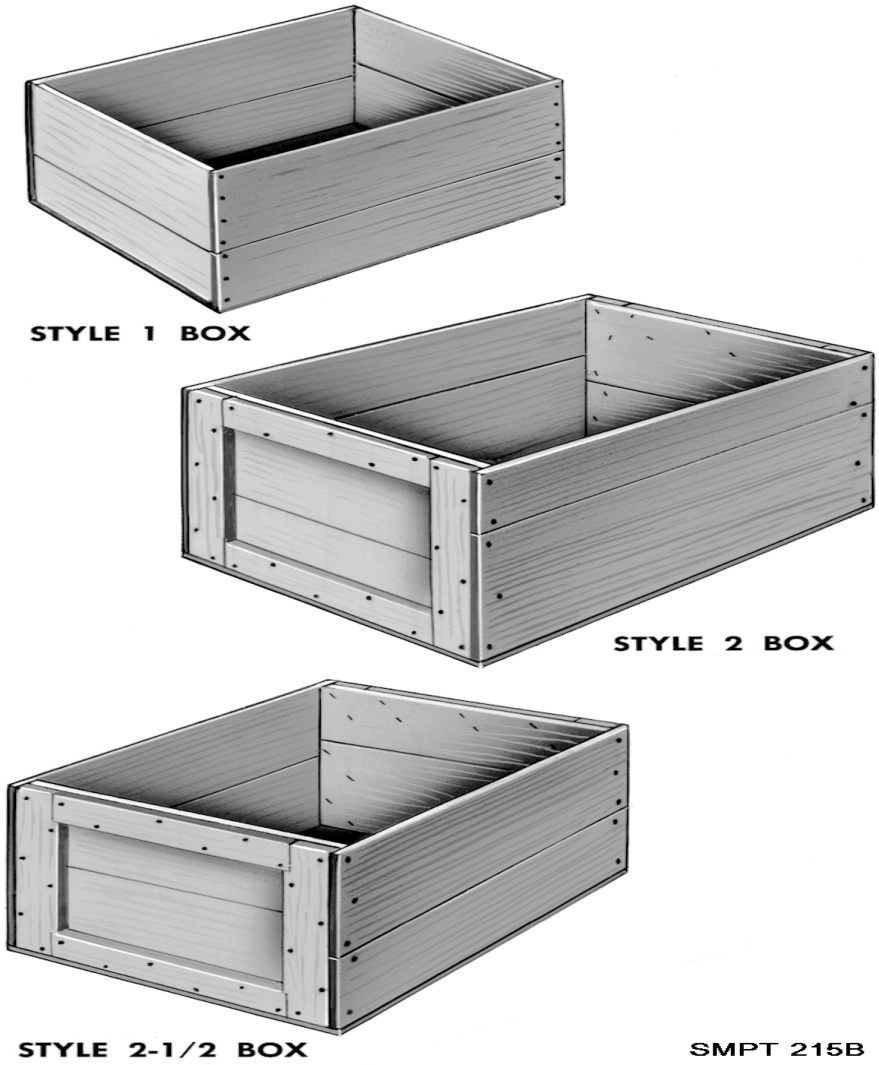

Figure 3-6. Styles of nailed woods boxes.

Style 2 1/2 Box (fig. 3-6)

Style 2 1/2 box is identified by two vertical notched cleats and two horizontal cleats on each end. It has the same advantages as the Style 2 box but is slightly higher in cost. Vertical cleats are notched approximately one-fourth to three-eighths inch to support the horizontal cleats. Vertical cleats are positioned one-eighth inch above the bottom edge of the end. Weight limitation for Style 2 1/2, Class 1 box (domestic) is 600 pounds. Weight limitation for Style 2 1/2, Class 2 box (oversea) is 1,000 pounds.

Style 4 Box (fig 3-7)

Style 4 box is identified by two vertical cleats on each end. Vertical cleats, which are positioned at right angles to the grain of the end, are one-eighth inch shorter than the outside surfaces of the top and bottom of the box. The top and bottom cover the sides. They fit between the cleats and are attached to the ends by straightline, side-grain nailing. The sides overlap the ends and cleats, providing for a staggered nailing pattern. Weight limitation for Style 4, Class 1 box (domestic) is 250 pounds. Weight limitation for Style 4, Class 2 box (oversea) is 400 pounds.

Style 4 1/2 Box (fig 3-7)

Style 4 1/2 box is identified by two horizontal end cleats. Horizontal cleats, which are positioned at right angles to the grain of the end, are one-eighth inch shorter than the outside surface of the sides. The sides extend over the ends, and provide for straight-line, side-grain nailing. The top and bottom extend over the ends and cleats, an provide for both side- and end-grain nailing. Weight limitations for both classes of boxes are the same as for Style 4 boxes.

Style 5 Box (fig 3-7)

Style 5 box is identified by interior vertical cleats. The cleats extend to within one-eight inch from the top and bottom edges of the end of the box. Other than the placement of cleats, construction and nailing pattern for this container is the same as for Style 4 box. The interior cleats may be rectangular or triangular, provided the cross section area of the triangular cleat is not less than that of the required rectangular cleat. Weight limitation for Style 5, Class 1 box (domestic) is 250 pounds. Weight limitation for Style 5, Class 2 box (oversea) is 400 pounds.

Style 6 Box (fig 3-7)

Style 6 box is identified by the lockcorner construction which is glued. This box has about the same advantages and disadvantages as Style 1 box. Style 6 box is intended for domestic shipments only and Type 1 and 2 loads. This box has a weight limitation of 50 pounds, but may go to 100 pounds if the box has one-piece sides.

Style 7 Box (fig 3-8)

Style 7 box is an internally reinforced box consisting of a skidded base with a separate hood assembled from the top, sides and ends. Style 7 boxes are for contents ranging from 100 to 1,000 pounds. The contents must readily permit attachment to the skids. The base is assembled to 2 X 4 inch skids to facilitate mounting to a skid base. The skids are positioned across the extreme ends of the bottom pieces to permit attachment of all end pieces to the skid edges. Vertical and horizontal framing members and reinforcing members in the form of a rectangle, and cross diagonals, as applicable, are attached to the interior surfaces of the prefabricated box panels. Framing members are required when contents exceeds 250 pounds or when side length is greater than end length.

End panels are identified by vertical sheathing which extends within one-eighth of an inch of each skid bottom. The hood assembly is placed over the item mounted to the base, then nailing and strapping is accomplished. Style 7 boxes are intended for both Class 1 and Class 2 use.

Shallow Box (fig 3-9)

When the inside depth of a box is five inches or less, cleats are not used. If cleats were applied to shallow boxes, they would be so small that in attaching them to the ends they would split. The end of the box may be made of one piece, or if the end is approximately square, it may be made of two pieces placed so that the grain runs in opposite directions. For Style 2, 2 1/2, 3, 4, and 4 1/2 boxes, the thickness of the ends shall be not less than the combined thickness of the end and cleat, as specified. Slides overlap the ends. Top and bottom overlap the sides and ends. Top, bottom, and sides are attached to the ends by staggered nailing. Weight limitation is 1,000 pounds for oversea shipments.

Construction Details

When nailed wood boxes are built locally, use the following information for constructing and closing the various styles. If purchased and received in shook form, the sides, top, an bottom will be ready to be attached to the constructed ends. Figure 3-10 shows the amount of acceptable splitting allowed in the component parts.

Figure 3-7. Styles of nailed wood boxes.

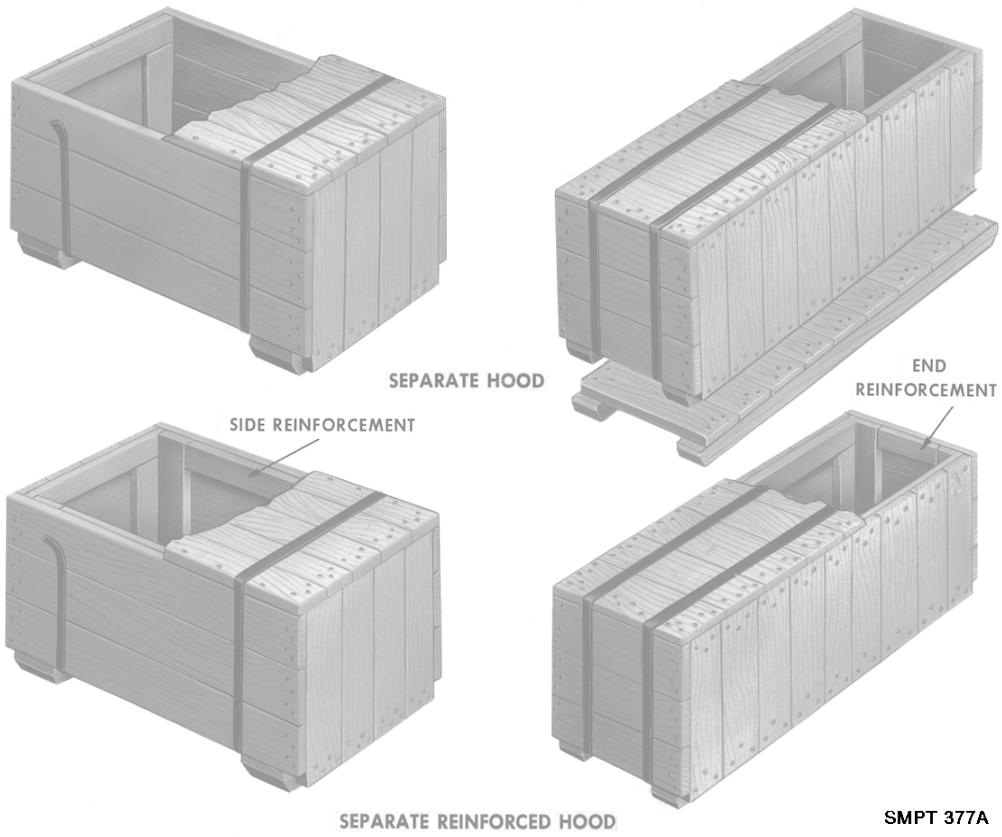

Figure 3-8. Style 7 nailed wood box.

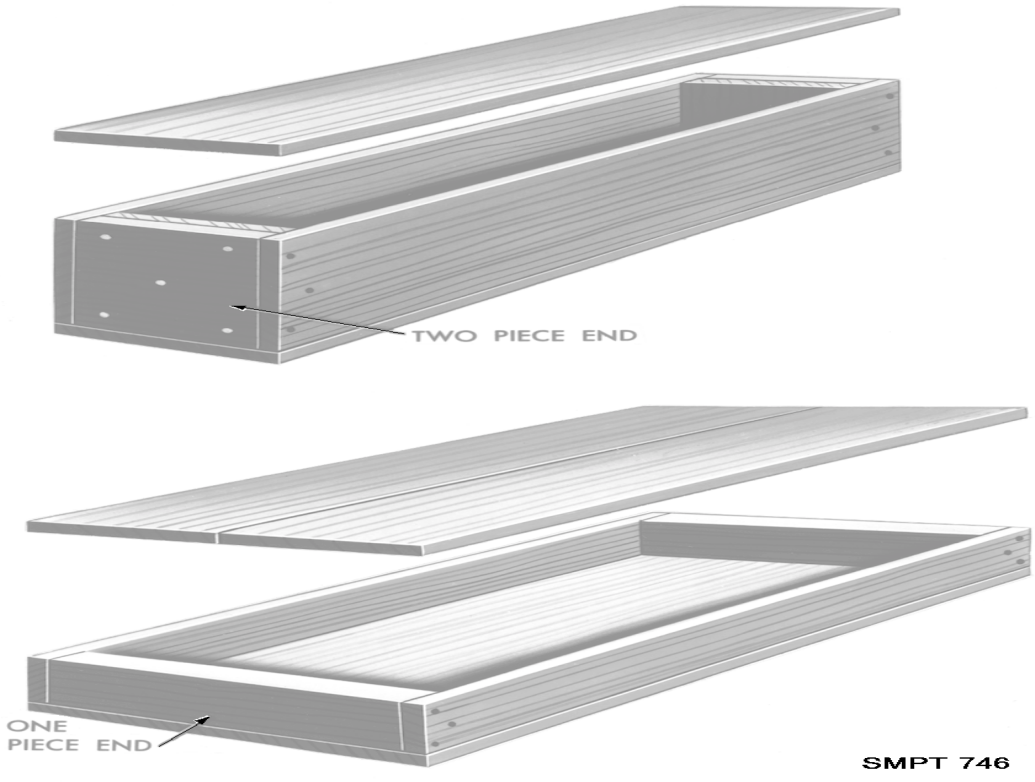

Figure 3-9. Shallow boxes.

Size of lumber

The size of lumber used in nail wood box construction is found in tables 3-1, 3-2, 3-3, and 3-4. Information necessary to use these tables is: Class of box, type of load, net weight, style of box, and group of wood.

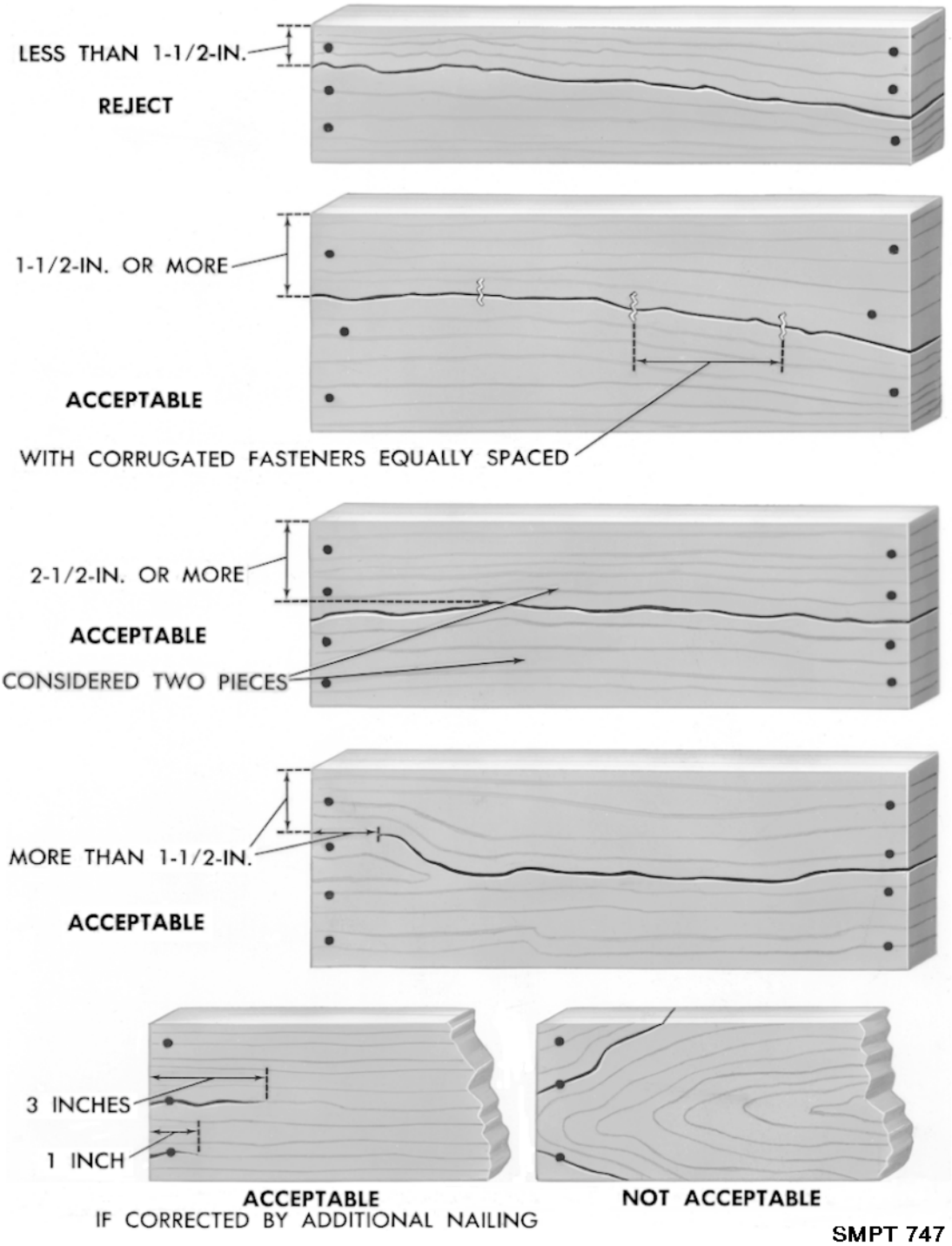

Figure 3-10. Split board rules

Construction Of Built-Up Faceboard Pieces (Fig 3-11)

The number of pieces in any side, top, bottom, or end will be chosen so that no single solid piece or built-up piece shall be less than 2 1/2 inches in width measured across the face, and will not exceed the number given in table 3-5. Built-up face-board pieces may be constructed according to the following conditions:

- The Linderman joint when glued.
- Butt joints glued under pressure.
- Tongued and grooved joints glued under pressure.
- Tongued and grooved joints glued with two or more corrugated fasteners driven from one side.
- Tongued and grooved unglued joints with two or more corrugated fasteners driven from alternate sides.

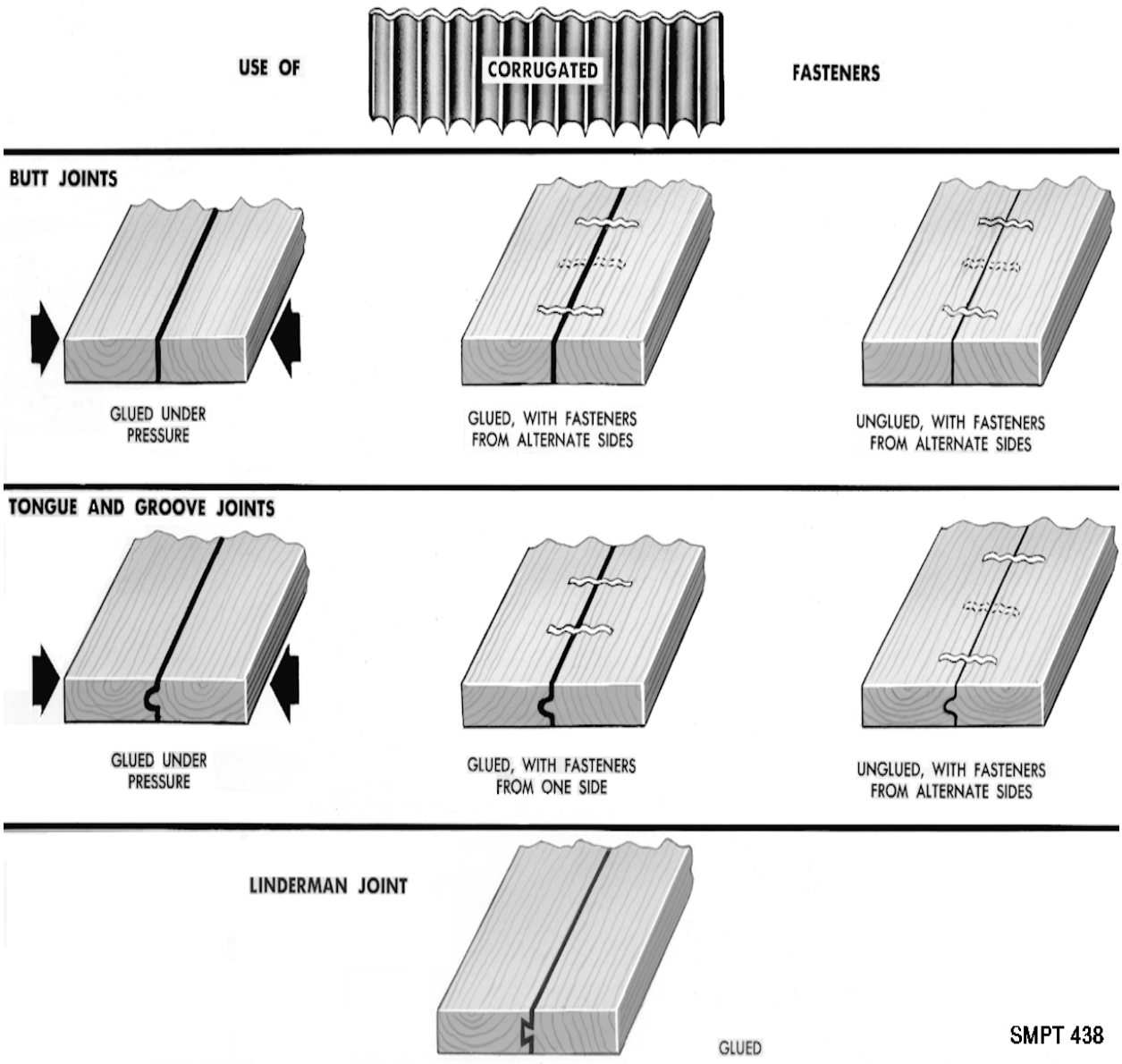

Figure 3-11. Joined pieces of lumber.

Table 3-1. Boxes for domestic shipment, type 1 (easy) and type 2 (average) loads; thickness of sides, tops, bottoms, and ends, and thickness and width of cleats.

Weight of contents		Style of Box[6]	Groups I and II woods[1]			Groups III and IV woods[2]		
Exceeding	Not exceeding		Thickness of sides, tops, and bottoms	Thickness of ends	Thickness and width of cleats	Thickness of sides, tops, and bottoms	Thickness of ends	Thickness and width of cleats[3]
Pounds	Pounds		Inch	Inch	Inches	Inch	Inch	Inches
--	50	1	3/8	1/2	--	1/4	1/2	--
--	50	4,4-1/2,5	3/8	1/2	1/2 by 2	1/4	1/2	1/2 by 1-3/4
--	50	2	3/8	3/8	3/8 by 2	1/4	3/8	3/8 by 1-3/4
--	50	6	3/8	1/2	--	1/4	3/8	--
50	100	1[4]	3/8	1	--	3/8	3/4	--
50	100	4,4-1/2,5	3/8	5/8	5/8 by 3	3/8	1/2	1/2 by 1-3/4
50	100	2,2-1/2	3/8	1/2	1/2 by 2	3/8	1/2	1/2 by 1-3/4
50	100	6[4]	3/8	1	--	3/8	1/2	--
100	250	4,4-1/2,5	1/2	5/8	5/8 by 3	1/2	1/2	1/2 by 2-1/4
100	250	2, 2-1/2,7	1/2	5/8	5/8 by 3	1/2	1/2	1/2 by 1-3/4
250	400[5]	2, 2-1/2,7	5/8	1	1 by 3	1/2	3/4	3/4 by 2-1/4

[1]Nominal. The dressed sizes of wood shall equal or exceed the minimum sizes shown in Table I of 20-70. For the purpose of this specification, reference to STD 20-70 shall be limited to the above.
[2]Thickness tolerance shall be " 1/16 inch for parts 3/8 inch thick and thicker, except as otherwise specified. Thickness tolerance shall be + 1/16 - 1/32 inch for pieces less than 3/8 inch thick.
[3]Width tolerance shall be " 1/16 inch, except as otherwise specified.
[4]Providing the boxes have one-piece solid sides of sawed lumber and contents are packed in interior containers.
[5]When load to be carried by the box exceeds 400 pounds, use Table 3-3; when load exceeds 600 pounds, use Table 3-4.
[6]Styles 2, 2-1/2, 4, 4-1/2 boxes. Unless otherwise specified, when the inside depth of a box is 5 inches or less, end cleats shall not be used. Thickness of the ends shall be not less than the combined thickness of the end and cleat, as specified. Each side and end shall be made from one piece, except when the end is approximately square, a two-piece end may be used with each end piece of approximately equal thickness, and with the grain of each piece running at right angles to the other. Two-piece ends shall be nailed together with at least two clinched nails.

Table 3-2. Boxes for domestic shipment, type 3 (difficult) loads; thickness of sides, top, bottoms, and ends, and thickness and width of cleats.

Weight of contents		Style of Box[5]	Groups I and II woods[1]			Groups III and IV woods[2]		
Exceeding	Not exceeding		Thickness of sides, tops, and bottoms	Thickness of ends	Thickness and width of cleats	Thickness of sides, tops, and bottoms	Thickness of ends	Thickness and width of cleats[3]
Pounds	Pounds		Inch	Inch	Inches	Inch	Inch	Inches
-	50	4,4-1/2,5	3/8	5/8	5/8 by 2	3/8	1/2	1/2 by 1-3/4
50	100	4,4-1/2,5	1/2	1	1 by 3	1/2	1/2	1/2 by 1-3/4
50	100	2,2-1/2	1/2	5/8	5/8 by 2	1/2	1/2	1/2 by 1-3/4
100	250	4,4-1/2,5	5/8	1	1 by 3	1/2	3/4	3/4 by 2-1/4
100	250	2,2-1/2,7	5/8	1	1 by 3	1/2	1/2	1/2 by 2-1/4
250	400	2,2-1/2,7	1	1	1-1/4 by 4	3/4	3/4	3/4 by 2-1/4
400	600[4]	2,2-1/2,7	1	1	1-1/4 by 4	3/4	3/4	3/4 by 2-5/8

1Nominal. The dressed sized of the wood shall equal or exceed the minimum sizes shown in Table I of STD 20-70. For the purpose of this specification, reference to STD 20-70 shall be limited to the above.
[2] Thickness tolerance shall be " 1/16 inch, for parts 3/8 inch thick and thicker unless otherwise specified.
[3]Width tolerance shall be " 1/16 inch, unless otherwise specified.
[4]When load to be carried by the box exceeds 600 pounds, use Table 3-4.
[5]Styles 2, 2-1/2, 4, 4-1/2 boxes. Unless otherwise specified, when the inside depth of a box is 5 inches or less, end cleats shall not be used. Thickness of the ends shall be not less than the combined thickness of the end and cleat, as specified. Each side and end shall be made from one piece, except when the end is approximately square, a two-piece end may be used with each end piece of approximately equal thickness, and with the grain of each piece running at right angles to the other. Two-piece ends shall be nailed together with at least two clinched nails.

Table 3-3. Boxes for overseas shipment, type 1(easy) and type 2 (average) load; thickness of sides, tops, bottoms, and ends, and thickness and width of cleats.

Weight of contents		Style of box[1]	Groups I and II woods[2]			Groups III and IV woods[3]		
Exceed-ing	Not exceed-ing		Thickness of sides, tops, and bottoms 2/	Thickness of ends 2/	Thickness and width of cleats 2/	Thick-ness of sides, tops, and bottoms	Thickness of ends	Thickness and width of cleats 4/
Pounds	Pounds		Inch	Inch	Inches	Inch	Inch	Inches
--	50	4,4-1/2,5	3/8	5/8	5/8 by 2	3/8	1/2	1/2 by 1-3/4
50	100	4,4-1/2,5,7	1/2	1	1 by 3	3/8	1/2	1/2 by 1-3/4
100	250	4,4-1/2,5	5/8	1	1 by 3	1/2	3/4	3/4 by 2-1/4
100	250	2,2-1/2,7	5/8	5/8	5/8 by 3	1/2	1/2	1/2 by 2-1/4
250	400	4,4-1/2,5	1	1	1 by 3	3/4	3/4	3/4 by 2-1/4
250	400	2,2-1/2,7	1	1	1 by 3	3/4	3/4	3/4 by 2-1/4
400	600	2,2-1/2,7	1	1	1 by 3	3/4	3/4	3/4 by 2-1/4
600	1000	(see Table 3-4)						

c[1]Styles 2, 2-1/2, 4, 4-1/2 boxes. Unless otherwise specified, when the inside depth of a box is 5 inches or less, end cleats shall not be used. Thickness of the ends shall be not less than the combined thickness of the end and cleat as specified. Each side and end shall be made from one piece, except when the end is approximately square, a two-piece end may be used with each piece of approximately equal thickness, and with the grain of each piece running at right angles to the other. Two-piece ends shall be nailed together with at least two clinched nails.
[2]Nominal. The dressed sizes of the wood shall equal or exceed the minimum sizes shown in Table I of STD 20-70. For the purposes of this specification, reference to STD 20-70 shall be limited to the above.
[3]Thickness tolerance shall be plus or minimum "1/16 inch for parts 3/8 inch thick and thicker, unless otherwise specified.
[4]Width tolerance shall be " 1/16 inch unless otherwise specified.

Table 3-4. Boxes for overseas shipment, type 3 (difficult) load; thickness of sides, tops, bottoms, and ends, and thickness and width of cleats.

Weight of contents		Style of box[1]	Groups I and II woods[2]			Groups III and IV woods[3]		
Exceeding	Not exceeding		Thickness of sides, tops, and bottoms[2]	Thickness of ends[2]	Thickness and width of cleats[2]	Thickness of sides, tops, and bottoms	Thickness of ends	Thickness and width of cleats[4]
Pounds	Pounds		Inch	Inch	Inches	Inch	Inch	Inches
--	100	4,4-1/2,5	1/2	1	1 by 3	1/2	1/2	1/2 by 1-3/4
--	100	2,2-1/2,7	1/2	5/8	5/8 by 3	1/2	1/2	1/2 by 1-3/4
100	250	4,4-1/2,5	5/8	1	1 by 3	1/2	3/4	3/4 by 2-1/4
100	250	2,2-1/2,7	5/8	5/8	1 by 3	1/2	3/4	1/2 by 2-1/4
250	400	4,4-1/2,5	1	1-1/4	1-1/4 by 4	3/4	7/8	7/8 by 2-5/8
250	400	2,2-1/2,7	1	1	1-1/4 by 4	3/4	3/4	3/4 by 2-5/8
400	600	2,2-1/2,7	1	1	1-1/4 by 4	3/4	7/8	7/8 by 2-5/8
600	800	2,2-1/2,7	1	1-1/4	1-1/4 by 4	3/4	7/8	7/8 by 2-5/8
800	1000	2,2-1/2,7	1-1/4	1-1/2	1-1/2 by 5	7/8	1-3/8	1-3/8 by 3-1/4

[1]Styles 2, 2-1/2, 4, 4-1/2 boxes. Unless otherwise specified, when the inside depth of a box is 5 inches or less, end cleats shall not be used. Thickness of the ends shall be not less than the combined thickness of the end and cleat as specified. Each side and end shall be made from one piece, except when the end is approximately square, a two-piece end may be used with each piece of approximately equal thickness, and with the grain of each piece running at right angles to the other. Two-piece ends shall be nailed together with at least two clinched nails.
[2]Nominal. The dressed sizes of the wood shall equal or exceed the minimum sizes shown in Table I of STD 20-70. For the purposes of this specification, reference to STD 20-70 shall be limited to the above.
[3]Thickness tolerance shall be plus or minimum 1/16 inch for parts 3/8 inch thick and thicker, unless otherwise specified.
[4]Width tolerance shall be " 1/16 inch unless otherwise specified.

Table 3-5. Number of Pieces in any Box Part.

Width of box part		Maximum number of pieces single solid or built-up
Exceeding	Not exceeding	
Inches	Inches	
0.....	2-1/2.....	1
2-..1/2.....	5.....	2
5.....	7-1/2.....	3
7-1/2.....	12.....	4
12.....	.....	(See note)

Note: The width of pieces in box parts exceeding 12 inches the average width of pieces shall be not less thean 3 inches. No single solid or built-up piece shall be less than 2-1/2 inches in width across the space.

Additional Cleats and Battens

Additional cleats will be made of the same size lumber as the regular cleats. They are placed on the ends of a box when required, according to length of unsupported span (table 3-6). Additional cleats applied to ends run across the grain of the end (right angle to grain direction) and midway between the regular cleats. Battens are made of the same size lumber as regular cleats. Battens are used on the sides, top, and bottom when the limit of unsupported span is exceeded (table 3-6). Wherever possible, and without increasing the size of the container, battens should be placed inside the box. When battens are required to be placed on the outside of a box without skids, not less than two sets shall be attached across the sides, top, and bottom. They shall be applied so that those on the top and bottom extend over the ends of the side battens. They shall be located not less than 2 1/2 inches nor more than one-sixth the length of the box with respect to each box end. However, that distance and the interval between sets of battens shall be not more than maximum span specified in table 3-6. Exterior battens shall be applied to boxes with skids in the same manner as required for interior battens except that the bottom battens shall be fabricated from one piece of lumber a minimum of 2 1/2 inches high and 3 1/2 inches wide.

Diagonals (fig 3-12)

Sometimes diagonal reinforcing members are added to the interior or exterior surfaces of the box. Diagonals used on both the end and side panels are the same width and thickness as required for cleats and are nailed in the same manner. The presence of intermediate battens or cleats, required by table 3-6, determine the number of single diagonals on each panel. Single diagonals in each of two adjacent areas of one panel are arranged to peak at the center and bear at the upper end of the intermediate batten. Three or more diagonals in adjacent areas of one panel are arranged in a zigzag manner. When a 24-inch minimum strapping interval is required, the inner surface of the exterior diagonals must be notched slightly to permit the strapping to pass under each diagonal.

Skids

Boxes (except style 7) with items packed therein, having a gross weight in excess of 200 pounds, or containers with length and width dimensions of 48 inches by 24 inches or more and weighing more than 100 pounds, shall be provided with a minimum of two skids. The skids shall be fabricated from one piece of 2 1/2 inches high and 3 1/2 inches wide. Skids shall replace

exterior battens on box bottoms when battens are required in table 3-6. Skids shall be placed parallel to and extend the full width of the box and shall be positioned not closer than 2 1/2 inches nor more than one sixth the length of the box from each end of the box. The distance between skids, measured between the inside edges, shall not exceed the distance between battens, and when battens are not required, shall not exceed 48 inches. Additional skid(s), as required, shall be positioned so as to divide the distance between the end skids into units of equal length. When bolt fastening is provided for the item being packed, additional skids, as needed, shall be located on the box bottom so as to enable the item to be bolted through the skids. The skids shall be notched as applicable to provide clearance for either girthwise or lengthwise strapping. When 4-way fork entry is required, skids shall be a minimum of 3 1/2 inches high and 3 1/2 inches wide, cut out a minimum of 2 inches, in depth and of such width as to accommodate forks and slings for handling, and may be placed lengthwise flush with the box sides. The skids shall be secured to the box by nails. The nails shall be driven from the inside through the bottom into the skids and be clinched not less than 1/8 inch. Alternative to clinching, nails conforming to Type II, style 18 of ASTM F 1667-95 may be used of such length as to penetrate a minimum of 3/4 the thickness of the skids and shall not protrude through the skid. The nails shall be arranged in two rows in a staggered pattern, with space between nails in each row not to exceed 6 inches. Nails shall not be located less than 1/2 inch from edges of the skid nor less than approximately 1 1/2 inches from ends of the skid. Variation in specified thickness of skids may be plus or minus 1/8 inch and the variation in specified width of skids may be plus or minus 1/4 inch. When skids are specified and box requires 2 or more inside battens (table 3-6), the inside bottom battens need not be applied. However, a skid shall be attached to the outside of the box bottom placed in alignment with each side batten.

Table 3-6. Requirements for Additional Battens or Cleats.

Thickness of ends, side, top, or bottom		Maximum length of unsupported span
Groups I and II woods	Groups III and IV woods	
Inches	Inches	Inches
.....	1/4	19
3/8	.....	21
.....	3/8	23
1/2	.....	30
.....	1/2	34
5/8	.....	38
.....	5/8	42
.....	3/4	47
1	.....	50
.....	13/16	54
1-1/4	7/8	64

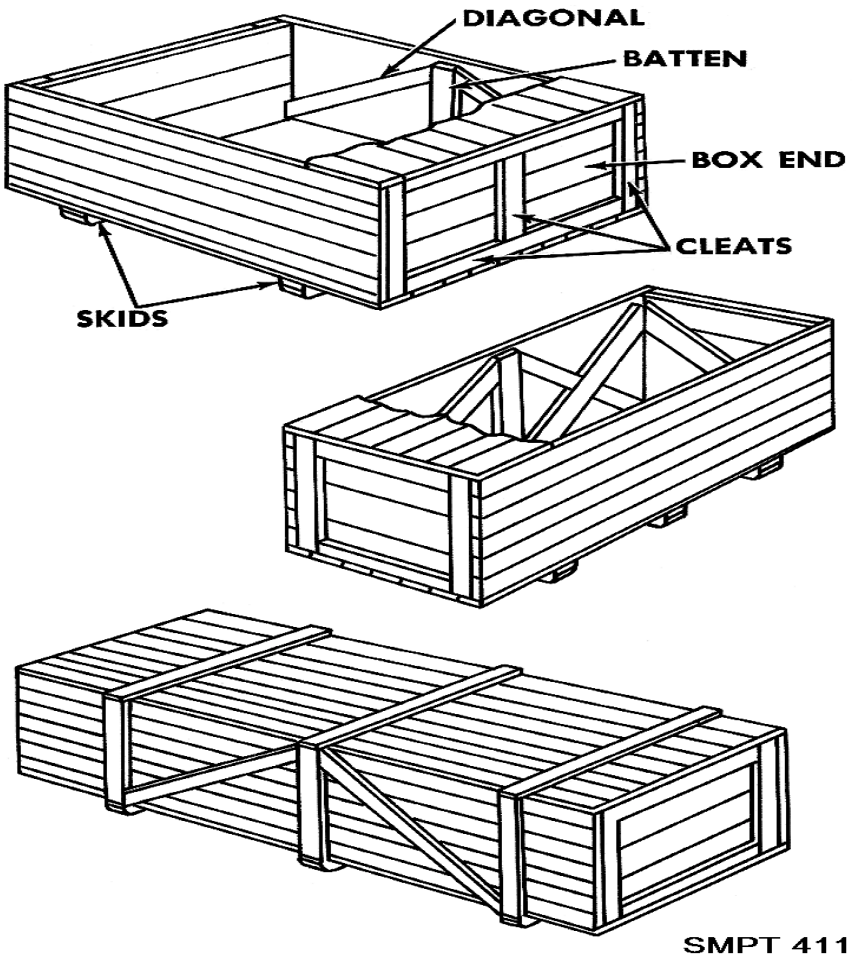

Figure 3-12. Style 2 reinforced box.

NAILING REQUIREMENTS

SPACING AND SIZES

Nail spacing and sizes will conform to tables 3-8 and 3-9.

NAILING OF TOP AND BOTTOM

When specified, the top and bottom should be nailed to the box sides.

NAIL SIZES

Sizes of nails are determined from the following information:

- Nail sizes for fastening sides, top, and bottom to ends and cleats are determined by the group of wood and thickness of the pieces being fastened together (table 3-7).
- Nail sizes to secure top and bottom to the sides are determined from the group of wood being used and the thickness of the side (table 3-8).
- Nails to fasten cleats to the ends will be long enough to penetrate both the cleat and the end and be clinched at least one-eighth of an inch. However, when eightpenny nails or smaller are used, they may be clinched not more than three-eighths inch.
- If correct nail size is not available, or splitting is encountered, one size smaller is used, and the spacing will be one-fourth of an inch closer.

NAIL SPACING

The spacing of nails is determined from the following:

- Nail spacing for fastening sides, top, an bottom to the ends will depend on the size of nails used, and whether driven into side-grain or end-grain. If nails are driven into both side- and end-grain, the spacing is the same as for end-grain nailing (table 3-9).
- Nail spacing for fastening the top and bottom to the sides of the box is determined from the thickness of sides. If the thickness of the sides is less than three-fourths of an inch, no nailing is permitted. There is a minimum and maximum spacing (table 3-8).

When attaching cleats and battens, the nails are driven in two parallel rows spaced alternately as given in table 3-9, so that the end nails are not less than three-fourths of an inch from the end of the cleat or batten. All nails shall pass through both the cleat and the end (or batten and side, top and bottom) and be clinched. Nails are driven approximately three-eighths of an inch from the edge when the cleat or batten is 2 inches or under in width, and one-half of an inch when it is over 2 inches in width.

NAILING RULES

It is imperative that poor nailing practices be avoided and correct nailing procedures be followed. Both are shown in figures 3-13 and 3-14, and stressed in the following rules:

- Each single solid piece or built-up piece in the sides, top, or bottom will have at least two nails or other acceptable fastener at each end.
- Each single piece or built-up piece is fastened to each vertical cleat or batten with not less than two nails or other acceptable fastener.
- Wherever possible, side-grain nailing should be accomplished. In nailing to both the end and the cleats, at least half of the nails are driven into the cleat.
- Where a cleat is attached to an end, at least one end nail will be adjacent to the inside edge of the cleat.
- Nails are clinched across the grain of the wood, if possible.
- Nails must be driven so that neither the head nor the point will project above the surface of the wood.
- Occasionally, overdriven nails are permitted. Nails overdriven more than one-eighth the thickness of the piece are not permitted.
- Cement-coated or chemically-etched nails have a holding power considerably greater than that of uncoated and consequently 25 percent more nails of the same size are needed when smooth nails are used in place of cement-coated or chemically-etched nails. The comparative holding power of nails is illustrated in figure 3-15. Bright, uncoated nails must be clinched.

Table 3-7. Size of cement-coated or chemically-etched cooler, sinker, and standard box nails for boxes.

Species of wood	Thickness of ends or cleats to which sides, tops and bottoms are nailed (inch)											
	Exceeding	....	7/16	1/2	9/16	5/8	11/16	13/16	7/8	1	1-1/8	1-1/4
	Not exceeding	7/16	1/2	9/16	5/8	11/16	13/16	7/8	1	1-1/8	1-1/4	.....
Group I.....	Size of nail (penny)	4	5	5	6	7	8	8	9	9	10	12
Group II.....		4	4	5	5	6	7	7	8	9	9	12
Group III.....		3	4	4	5	5	6	7	7	8	9	10
Group IV.....		3	3	4	4	4	5	6	7	8	8	9

Table 3-8. Size of nails and spacing for nailing tops and bottoms to sides of boxes.

Thickness of side (inches)	Group I wood	Group II wood	Groups III and IV woods	Spacing	
				Minimum	Maximum
Under 3/4.....	No nailing permitted				
3/4 thru 7/8 incl.....	7d	6d	5d	6	8
15/16 thru 1-1/16 incl.....	8d	7d	6d	6	8
Over 1-1/16.....	10d	9d	8d	8	10

Table 3-9. Spacing of cement-coated or chemically-etched nails for boxes.

Size of Nails	Spacing when driven into side grain	Spacing when driven into end grain[1]
	Inches	Inches
Sixpenny or smaller	2	1-3/4
Sevenpenny.....	2-1/4	2
Eightpenny.....	2-1/2	2-1/4
Ninepenny.....	2-3/4	2-1/2
Tenpenny.....	3	2-3/4
Twelvepenny.....	3-1/2	3
Sixteenpenny.....	4	311/2
Twentypenny.....	4-1/2	4

[1]When nails are alternately driven into end-grain of end and side-grain of cleat (such as nailing sides to ends in Styles 2, 2-1/2, 3, 4, 4-1/2, 5 and 7) use spacing based on driving nails into end-grain.

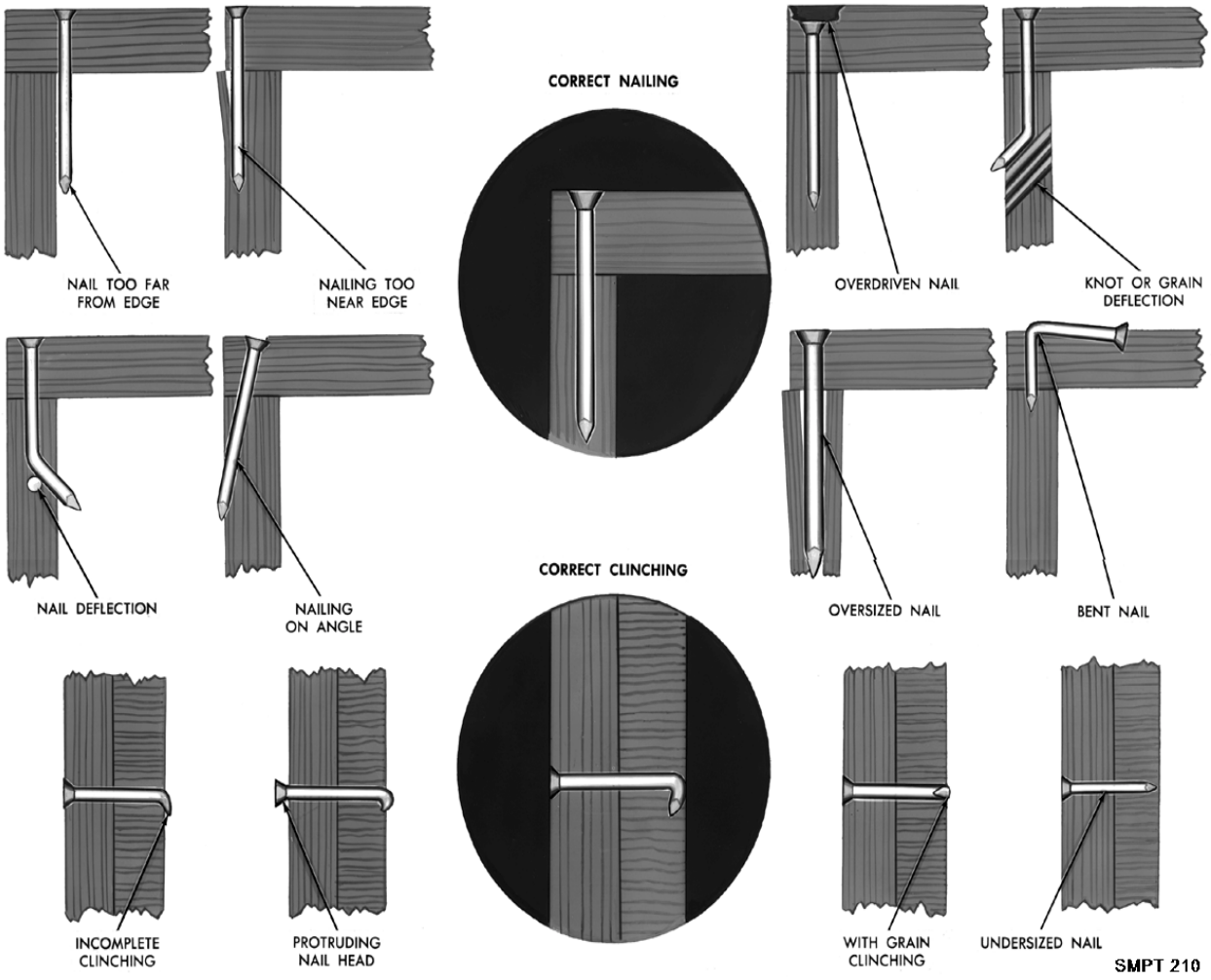

Figure 3-13. Nailing.

SETTING UP OF STYLE 1 AND 6 BOXES

The setting up of these styles is accomplished in the following order:

- Select nails and glue.
  - o Size of coated and etched nails and proper spacing is determined from tables 3-7, 3-8, and 3-9.
  - o Glue for securing sides to ends of Style 6, lock-corner box, is any commercially available water-resistant glue.
  - o Fasten the sides to the ends by straight-line nailing, using cement-coated or chemically-etched nails.
  - o Apply glue to both surfaces of the sides and ends of the lock-corners of Style 6 boxes.
  - o Nail the top and bottom.
  - o Use nails and proper spacing determined above.
  - o Secure the bottom of the box by nailing into the ends.
  - o After the load is inserted, secure the top of the box in the same manner as the bottom.

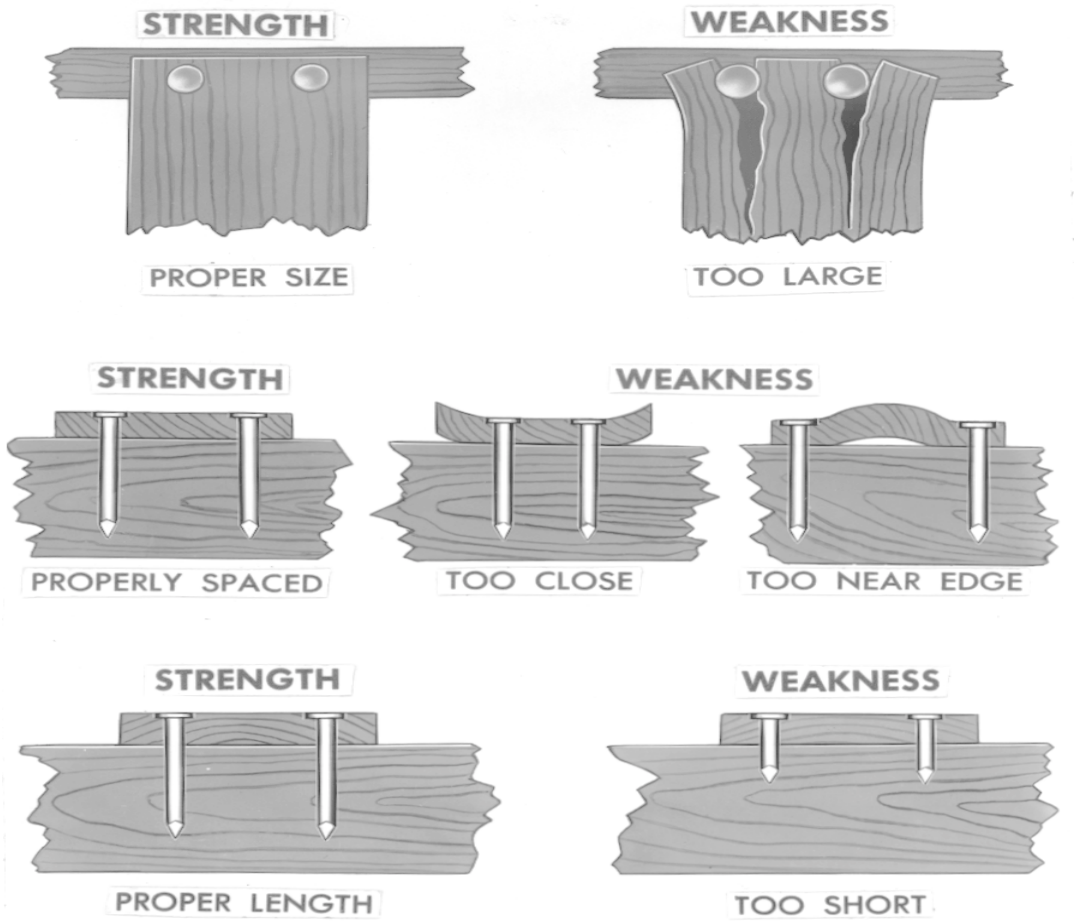

Figure 3-14. Proper and improper nailing.

SETTING UP OF STYLE 2 AND 2 1/2 BOXES

The setting up of these styles is accomplished in the following order:

- Select nails and proper spacing.
  - o Select proper size and spacing of coated or etched, and bright, uncoated nails from tables 3-7 and 3-8.
  - o Fasten the cleats to the ends.
  - o Nail cleats to end, using a staggered nailing pattern.
  - o Nails for nailing cleats to ends may be bright, uncoated, but must be clinched.
  - o Position the vertical cleats on the end at right angles to the grain of the end.
  - o Fasten the sides to the ends.
  - o Lap the sides over the ends and cleats.
  - o Nail the sides to the ends and cleats with coated or etched nails in a staggered pattern.
  - o Nail the top and bottom.
  - o Lap the top and bottom over the ends and cleats.
  - o Nail the top and bottom to the ends and cleats with coated or etched nails in a staggered pattern.

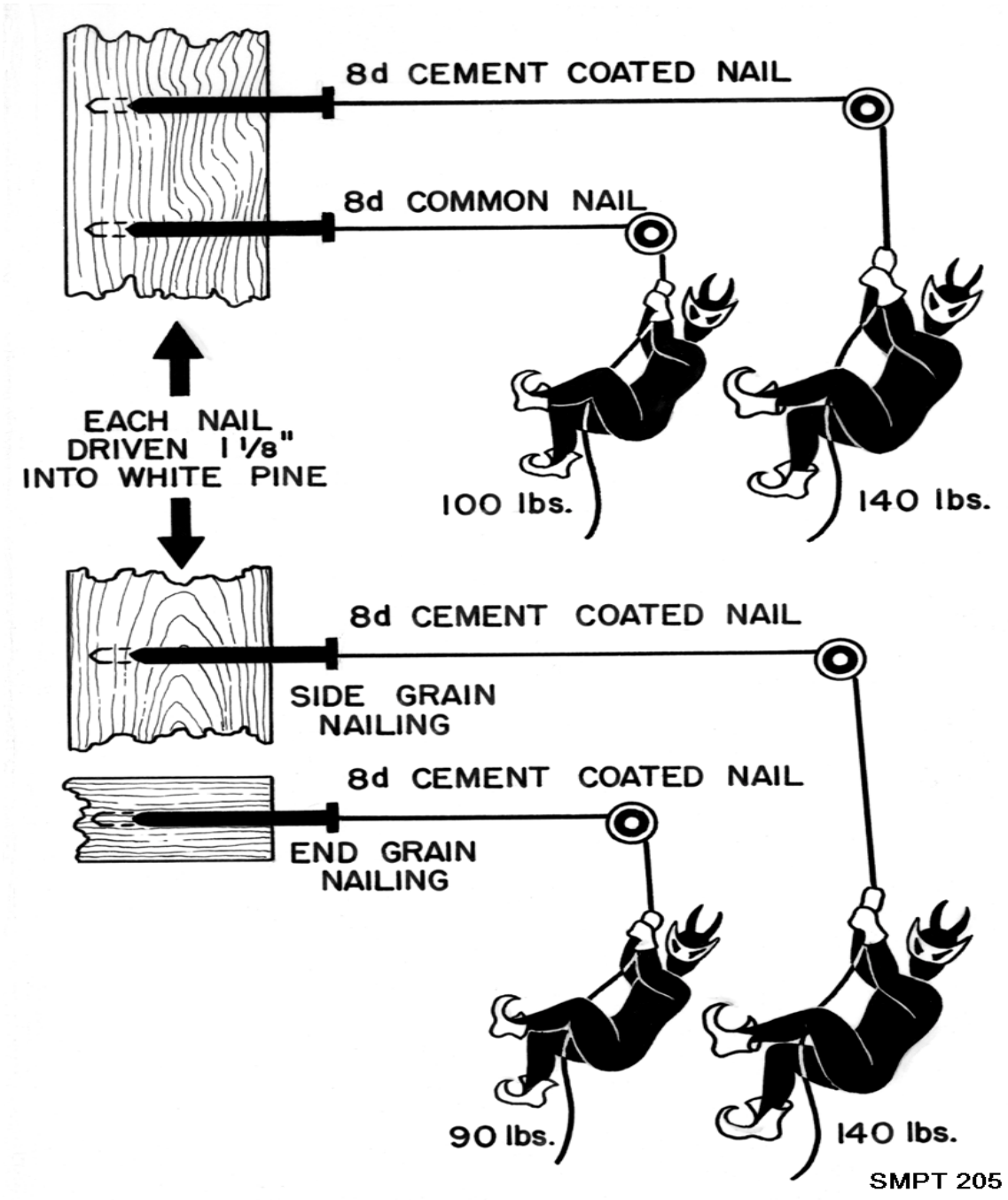

Figure 3-15. Nail holding power.

Setting up of style 4, 4 1/2, 5, and shallow boxes

The setting up of these styles is accomplished in the following order:

- Select nails and proper spacing. Select the proper size and spacing of coated or etched, and bright, uncoated nails from tables 3-7, 3-8, and 3-9.
- Fasten the cleats to the ends.
- Nail the cleats to the end using a staggering nailing pattern.
- Nails for nailing the cleats to the ends may be bright, uncoated, but must be clinched.
- Fasten the sides to the ends.
- Lap the sides over the ends and cleats on Style 4 and 5 boxes.
- Fasten the sides to the ends and cleats in a staggering nailing pattern.
- Lap the sides of Style 4 1/2 and shallow box over the ends.
- Drive the nails in a straight line for Style 4 1/2 box and in a staggered pattern for shallow boxes.
- Nail the top and bottom.
  - Nail the bottom of the box to the ends and sides.
  - On Style 4 and 5, boxes nail the top and bottom to the end with straightline nailing.
  - On Style 4 1/2 and shallow boxes, nail the top and bottom to the ends with a staggered nailing pattern.

Strapping Requirements

Strapping used on nailed wood boxes may be either round or flat. Proper size of strapping is determined by the net weight of contents and the number of straps used (tables 3-10 and 3-11). All straps are applied perpendicular to the edges of the box over which they pass and are drawn tight so as to sink into the wood at the edges. Straps shall be applied just prior to shipment where practicable. Strapping requirements are found in the Appendix to Specification PPP-B-621.

CLASS 1 (DOMESTIC) BOXES

Unless otherwise specified, Style 1 and 6 boxes, regardless of weight, and Style 2, 2 1/2, 4 4 1/2, 5, and 7 boxes, with weight of contents exceeding 100 pounds, shall be strapped. When specified, Style 2, 2 1/2, 4 4 1/2, and 5 boxes, with weight of contents less than 100 pounds, shall be strapped.

CLASS 2 (OVERSEA) BOXES

All boxes used for a shipment intended for overseas shall be strapped (fig 3-16).

Placement of Straps

On most boxes, the first straps are positioned girthwise about one-sixth of the length of the box from each end, not to exceed 9 inches from the ends.

On Styles 1 and 6, the first strap is lengthwise, followed by two girthwise straps.

When strapping is required on Style 7 boxes, one strap is applied parallel to, and immediately adjoining the inner edge of each skid. Three or more straps, equally spaced, are required when spacing between straps exceeds 24 inches.

Table 3-10. Minimum gage of round wire for various weights of boxes.

Net weight of contents		Gage of wire when differrent number of wires are used			
		Two bands		Three or more bands	
Exceeding	Not exceeding	Class B	Class A	Class B	Class A
Pounds	Pounds	Inch	Inch	Inch	Inch
0.....	70.....	0.0720 (15 gage)	0.0625 (16 gage)	0.0720 (15 gage)	0.0625 (16 gage)
70.....	125.....	0.0800 (14 gage)	0.0720 (15 gage)	0.0800 (14 gage)	0.0720 (15 gage)
125.....	175.....	0.0915 (13 gage)	0.0800 (14 gage)	0.0915 (13 gage)	0.0800 (14 gage)
175.....	250.....	0.0915 (13 gage)	0.0915 (13 gage)	0.0915 (13 gage)	0.0915 (13 gage)
250.....	400.....	0.1055 (12 gage)	0.0990 (12-1/2 gage)	0.0915 (13 gage)	0.0915 (13 gage)
400.....	1,000.....	.....	.....	0.1055 (12 gage)	0.0990 (12-1/2 gage)

Table 3-11. Minimum sizes of flat metal bands for various weigths of boxes.

Net weight of contents		Dimensions of flat metal bands when different numbers of bands are used	
Exceeding	Not exceeding	Two bands	Three or more bands
.....	70.....	3/8 by 0.015.....	3/8 by 0.015
70.....	125.....	3/8 by 0.020.....	3/8 by 0.020
125.....	175.....	1/2 by 0.020.....	1/2 by 0.020
175.....	250.....	5/8 by 0.020.....	5/8 by 0.020
250.....	400.....	3/4 by 0.020.....	3/4 by 0.020
400.....	1,000.....	.....	3/4 by 0.023

Additional straps are placed girthwise so that the distance between straps does not exceed 24 inches.

Small boxes less than 12 inches long and having less than 35 pounds of contents require only one girthwise strap. The single girthwise strap may be 16 gage round wire, or 3/8 X 0.010-inch flat strap.

When the outside length of unreinforced style 2, 2 1/2, 4, 4 1/2, 5 and shallow boxes exceeds 36 inches, three or more straps will be applied girthwise so that the distance between straps is not more than 24 inches.

Workmanship

Throughout the fabrication, setting up, nailing, and strapping of nailed wood boxes, good workmanship should be practiced at all times. Figure 3-17 shows some of the defects which must be avoided.

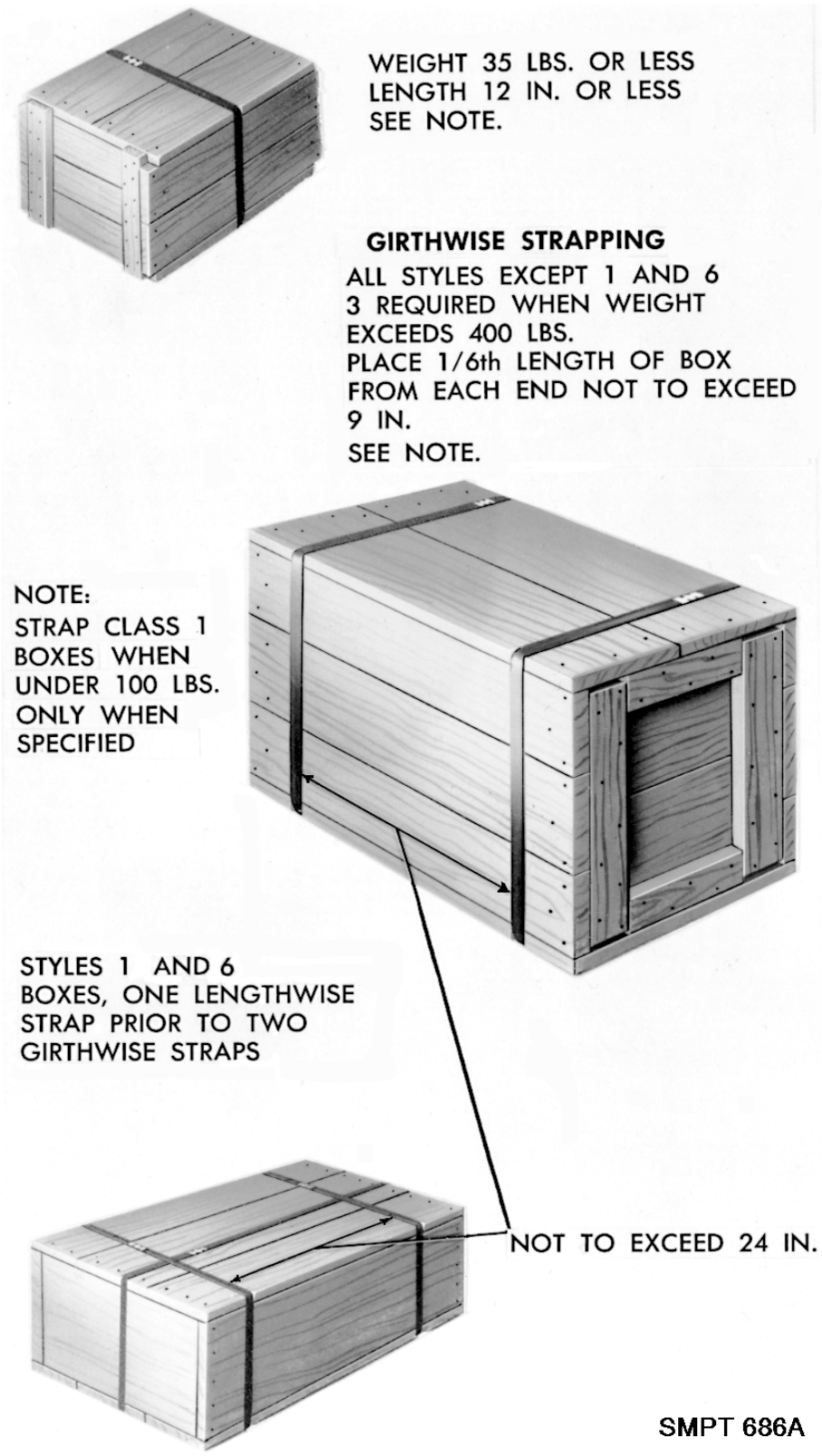

Figure 3-16. Strapping of nailed wood boxes.

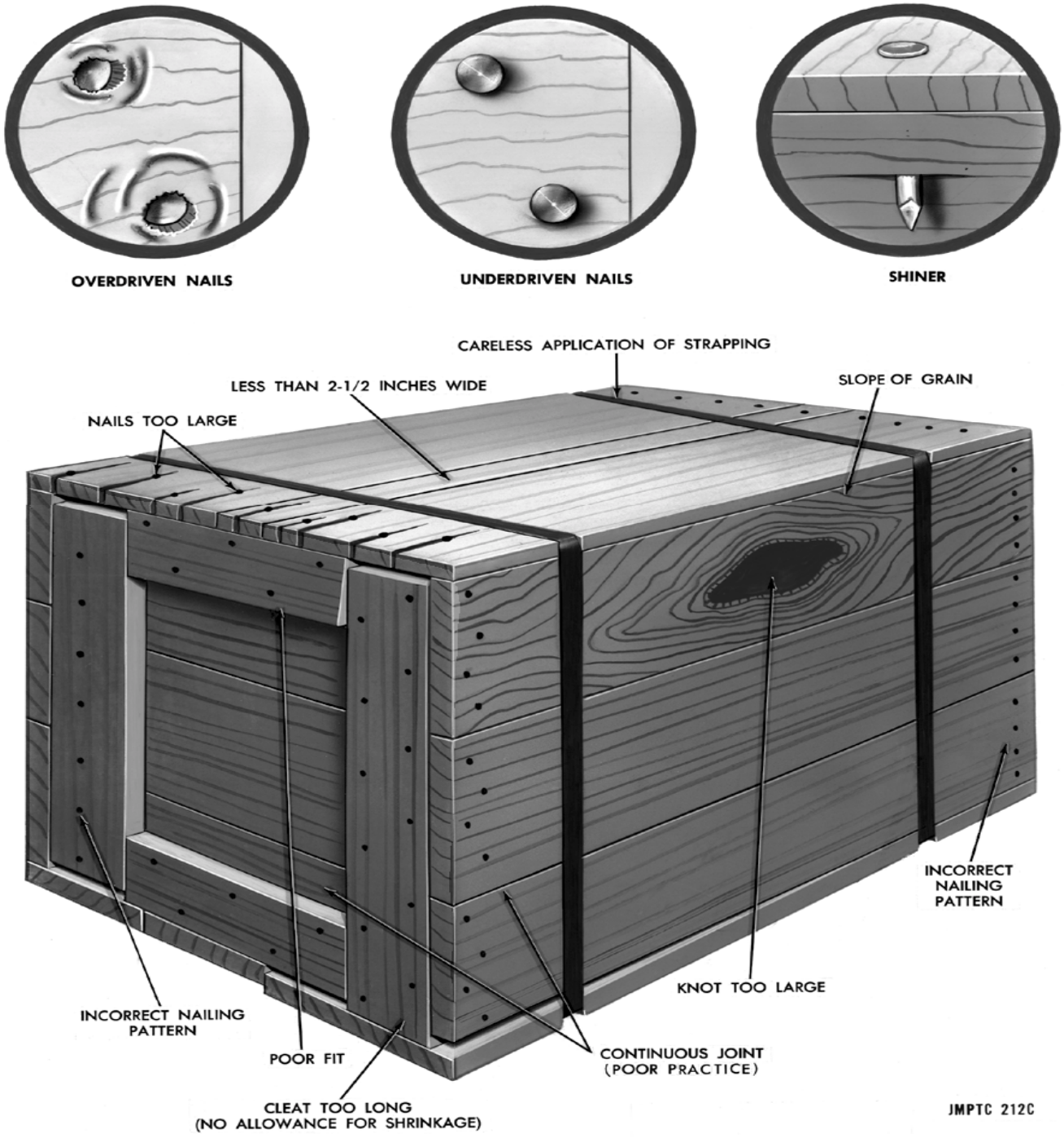

Figure 3-17. Defects of nailed wood boxes.

Preservation

When specified, each PPP-B-621 box or all of the finished wood parts shall be preserved by immersing for a minimum of one minute in one of the following wood preservative solutions: 2 percent copper Maphthenate, 3 percent zinc naphthenate, or 1.8 percent copper-8-quinolinolate. These three chemicals exhibit characteristics which are acceptable for DOD-wide use provided handling instructions prescribed by the manufacturer are followed. After the dip treatment, the boxes or wood parts must be air dried (or dried for an appropriate time in a kiln or oven) for a period of 24 hours minimum in a well-ventilated area allowing full air circulation around all surfaces of the individual wood box or wood part. The boxes or parts must be dried prior to shipment. Dryness can be determined by the absence of discoloration of the red oil soluble dye when tested as specified in PPP-B-621.

CLEATED-PANEL BOXES (GENERAL)

DESCRIPTION

Cleated-panel boxes are made by attaching wood cleats to sheets of plywood, fiberboard, or paper-overlaid veneer to form panels that are later fastened together at the cleats to form a container. When plywood is used as panel material, they are called wood-cleated plywood boxes, specification PPP-B-601; when fiberboard is used, they are called wood-cleated fiberboard boxes, specification PPP-B-576; and when paper-overlaid veneer is used, they are called wood-cleated, paper-overlaid veneer boxes. In each type of box, the cleats act to reinforce the edges and to aid in nailing.

CHARACTERISTICS

The chief characteristics of cleated-panel boxes are: Lightweight, high resistance to diagonal distortion, resistance to corner damage, and ability to withstand severe tumbling and dropping. They are easy to mark and handle, almost dustproof, and lend themselves to easy fabrication. Panels may be bought in large quantities in the knocked-down form, which can be easily stored in a minimum of space. These boxes afford three choices of cleated panel boxes for use in the shipping of military supplies and equipment. Selection of the panel material for the box is based upon the destination of the shipment, the minimum protection required, the weight of the item, and the container limitations.

Intended Uses and Limitations

The styles of boxes permitted for domestic and oversea shipments, with limitations for cleated plywood, cleated fiberboard, and cleated paper overlaid veneer boxes are cited in table 3-12.

Oversea Type Boxes (see figure 3-18)

Styles A and B are the only ones permitted, for cleated fiberboard and veneer. Cleated plywood boxes permit Styles A, B, I, and J. Plywood and paper-overlaid boxes will take all three types of loads. Cleated fiberboard boxes will take Type 1 and 2 loads only. Style A lends itself to ease of assembly and opening. Style B has greater strength, but is more difficult to open. The designs of these boxes and their load limit for oversea shipments are given in the respective container specifications.

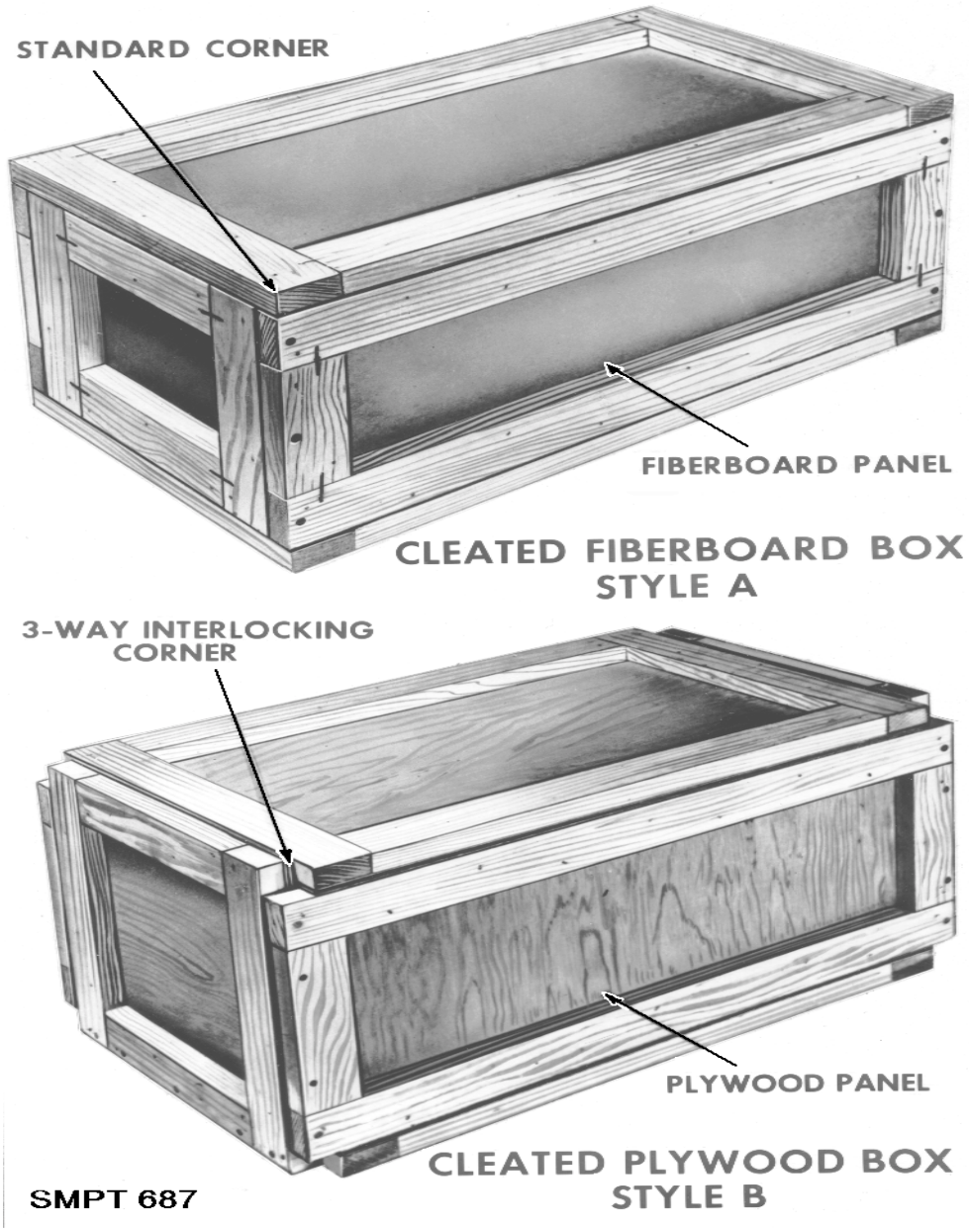

Figure 3-18. Oversea styles of cleated panel boxes.

Domestic Type Boxes (see figure 3-19)

Domestic boxes are intended f or normal use when the additional strength of the oversea type is not required. The selection of the style depends largely on the nature and weight of the item, and how it is to be supported. Styles B, D, E, and G have 3-way corners and are satisfactory if the boxes are not to opened for inspection and reclosed. If the boxes are to be opened and reclosed, Style A and K are preferred. The full-cleated Styles A and B are the strongest and most suitable for heavy items, if the weight can be applied over the entire area of any face. Styles A and B require only one size of nails for assembling the box, whereas, two sizes of nails are required for Styles C and K, inclusive. Paper-overlaid veneer boxes are only available in Styles A and B for domestic shipment. All three types of loads are permitted.